BTS guidelines for the management of spontaneous pneumothorax

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1 INTRODUCTION

Pneumothorax is defined as air in the pleural space—that is, between the lung and the chest wall.[1] Primary pneumothoraces arise in otherwise healthy people without any lung disease. Secondary pneumothoraces arise in subjects with underlying lung disease. The term pneumothorax was first coined by Itard, a student of Laennec, in 1803,[2] and Laennec himself described the clinical picture of pneumothorax in 1819.[2] He described most pneumothoraces as occurring in patients with pulmonary tuberculosis, although he recognised that pneumothoraces also occurred in otherwise healthy lungs, a condition he described as "pneumothorax simple". The modern description of primary spontaneous pneumothorax occurring in otherwise healthy people was provided by Kjaergard in 1932.[3] Primary pneumothorax remains a significant global problem, occurring in healthy subjects with a reported incidence of 18–28/100 000 per year for men and 1.2–6/100 000 per year for women.[4 5] Secondary pneumothorax is associated with underlying lung disease, whereas primary pneumothorax is not. By definition, there is no apparent precipitating event in either. Hospital admission rates for combined primary and secondary pneumothorax are reported in the UK at between 5.8/100 000 per year for women and 16.7/100 000 per year for men. Mortality rates in the UK were 0.62/million per year for women and 1.26/million per year for men between 1991 and 1995.[6] This guideline describes the management of spontaneous primary and secondary pneumothorax. It excludes the management of trauma. Algorithms for the management of spontaneous primary and secondary pneumothorax are shown in figs 1 and 2.

- **Strong emphasis should be placed on the relationship between the recurrence of pneumothorax and smoking in an effort to encourage patients to stop smoking. [B]**

Despite the absence of underlying pulmonary disease in patients with primary pneumothorax, subpleural blebs and bullae are likely to play a role in the pathogenesis since they are found in up to 90% of cases of primary pneumothorax at thoracoscopy or thoracotomy and in up to 80% of cases on CT scanning of the thorax.[7 8] The aetiology of such bullous changes in otherwise apparently healthy lungs is unclear. Undoubtedly, smoking plays a role[9–11]; the lifetime risk of developing a pneumothorax in healthy smoking men may be as much as 12% compared with 0.1% in non-smoking men.[11] This trend is also present, though to a lesser extent, in women.[11] There does not appear to be any relationship between the onset of pneumothorax and physical activity.[5] Small airway obstruction, mediated by an influx of inflammatory cells, often characterises pneumothorax and may become manifest in the smaller airways of men at an earlier stage.[12] Patients with primary pneumothoraces tend to be taller than control patients.[13 14] The gradient in pleural pressure increases from the lung base to the apex,[1] thus alveoli at the lung apex in tall individuals are subject to significantly greater distending pressure than those at the base of the lung and, theoretically, are more predisposed to the development of subpleural blebs.[15] Strong emphasis should be placed on the relationship between smoking and pneumothorax in an effort to deter those smokers who have developed a pneumothorax from smoking. Despite the apparent relationship between smoking and pneumothorax, 80–86% of young patients continue to smoke after their first primary pneumothorax.[16] The risk of recurrence of primary pneumothorax is 54% within the first 4 years, with isolated risk factors including smoking, height in male patients,[14 17] and age over 60 years.[17] Risk factors for secondary pneumothorax recurrence include age, pulmonary fibrosis, and emphysema.[17 18]

In an effort to standardise treatment of primary and secondary pneumothoraces, the British Thoracic Society (BTS) published guidelines for the treatment of both in 1993.[19] Several studies suggest that compliance with the 1993 guidelines, though improving, remains at only 20–40% among non-respiratory and A&E staff.[20–22] Clinical guidelines have been shown to improve clinical practice[23 24]; compliance with guidelines is related to the complexity of practical procedures that are described[25] and is strengthened by an evidence base.[26] Steps in the 1993 guidelines which may need clarification include: (1) simple aspiration (thoracocentesis) versus intercostal tube drainage (tube thoracostomy) as the first step in the management of primary and secondary pneumothoraces, (2) treatment of elderly pneumothorax patients or patients with underlying lung disease, (3) when to refer patients with a difficult pneumothorax to a chest physician or thoracic surgeon for persistent air leak or failure of re-expansion of the lung, and (4) treatment of the recurrent pneumothorax. This guideline addresses these issues. Its purpose is to provide a comprehensive evidence based review of the epidemiology, aetiology, and treatment of pneumothorax to complement the summary guidelines for diagnosis and treatment.

2 CLINICAL EVALUATION AND IMAGING

- **Expiratory chest radiographs are not recommended for the routine diagnosis of pneumothorax. [B]**

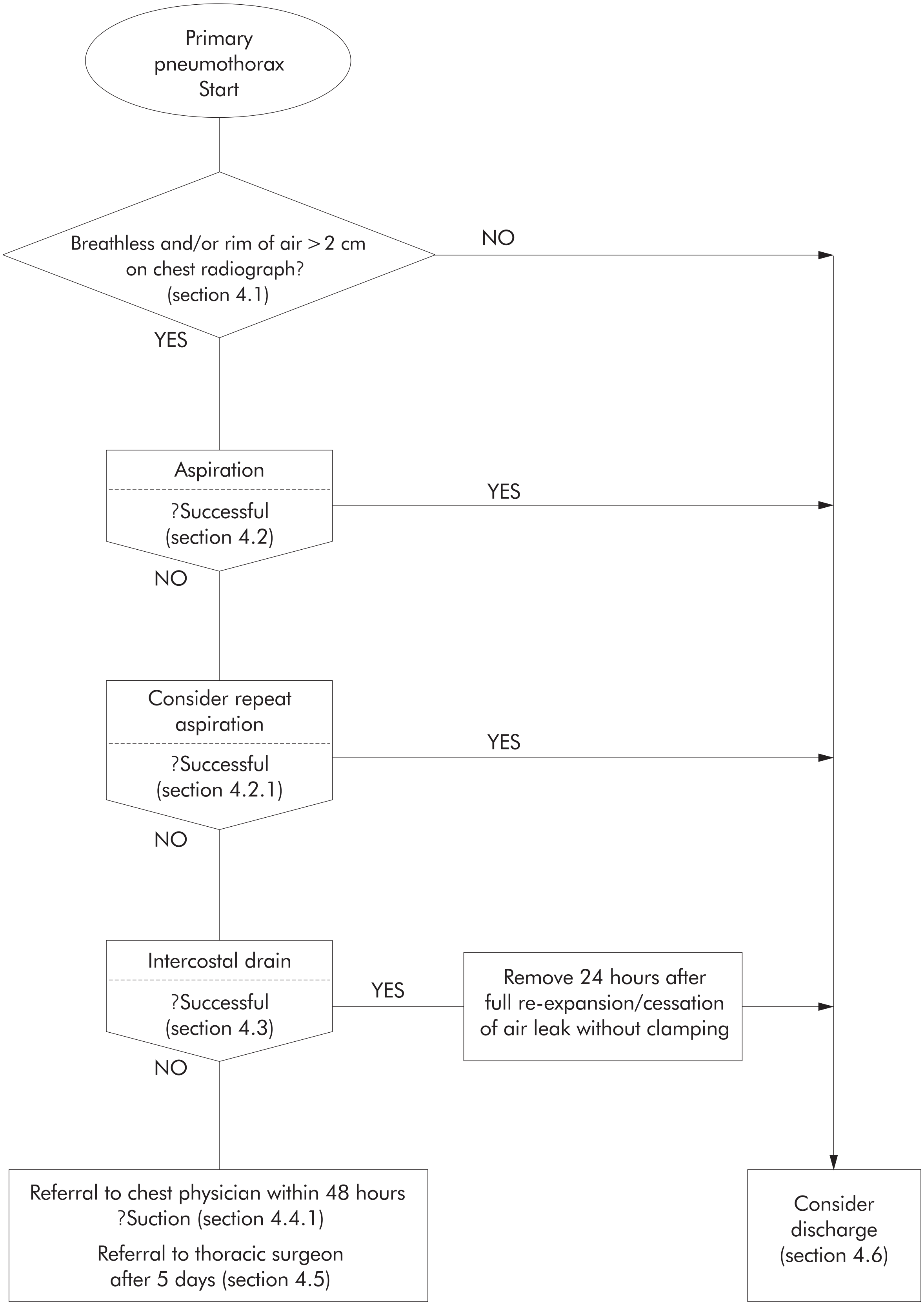


Figure 1 Recommended algorithm for the treatment of primary pneumothorax.

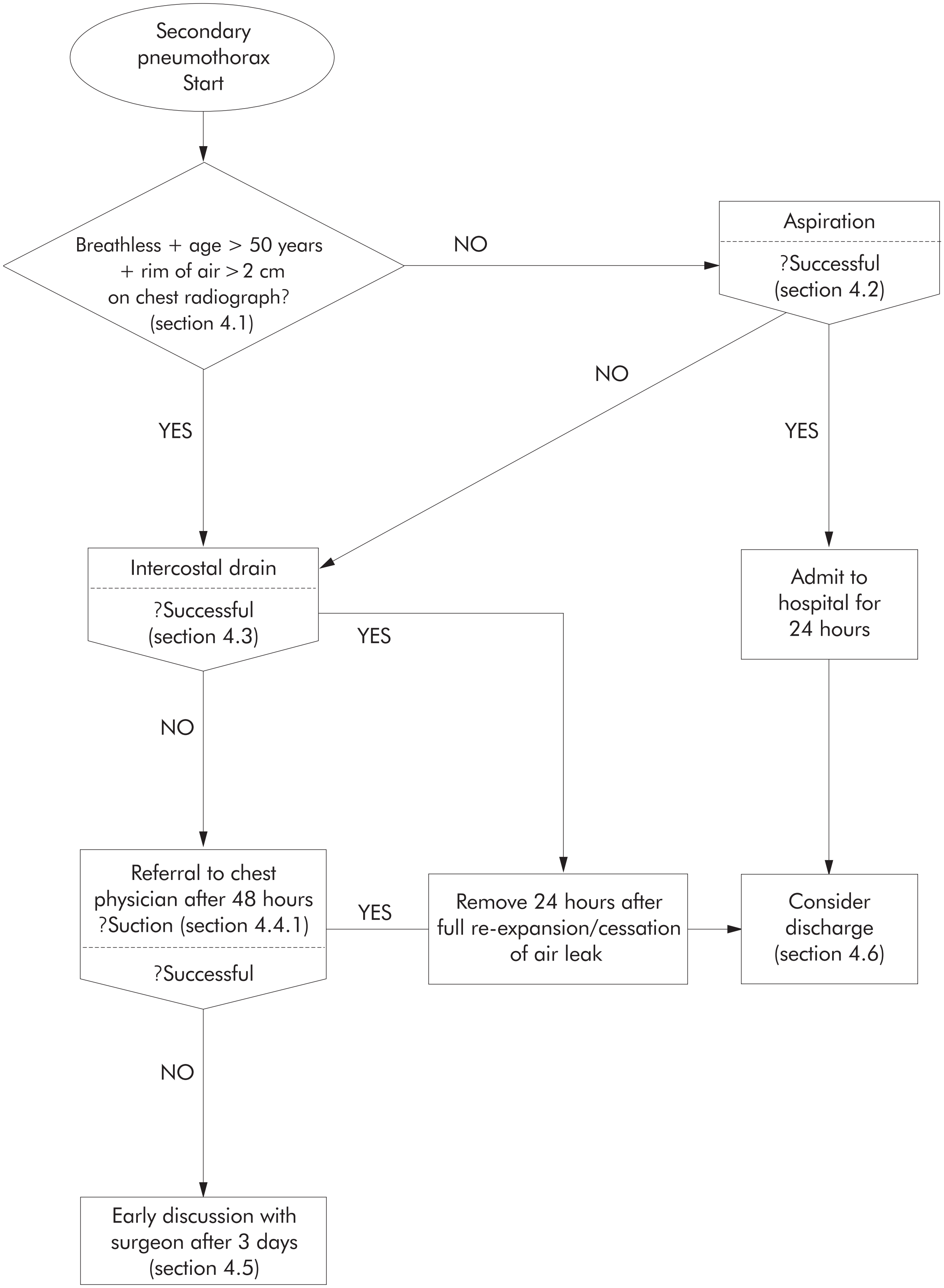


Figure 2 Recommended algorithm for the treatment of secondary pneumothorax.

- **A lateral chest or lateral decubitus radiograph should be performed if the clinical suspicion of pneumothorax is high, but a PA radiograph is normal. [B]**
- **CT scanning is recommended when differentiating a pneumothorax from complex bullous lung disease, when aberrant tube placement is suspected, and when the plain chest radiograph is obscured by surgical emphysema. [C]**
- **The clinical history is not a reliable indicator of pneumothorax size. [C]**

Clinical history and physical examination usually suggest the presence of a pneumothorax, although clinical manifestations are not reliable indicators of size.[29 30] In general, the clinical symptoms associated with secondary pneumothoraces are more severe than those associated with primary pneumothoraces, and most patients with a secondary pneumothorax complain of breathlessness which is out of proportion to the size of the pneumothorax.[31 32] Many patients, particularly those with primary pneumothoraces, do not seek medical advice for several days, 46% waiting more than 2 days with symptoms.[9] This feature is important because the occurrence of re-expansion pulmonary oedema (RPO) after re-inflation may be related to the length of time the lung has been collapsed (see section 4.4.1).[33 34]

Arterial blood gas measurements are frequently abnormal in patients with pneumothorax with the arterial oxygen tension (Pao_2) being less than 10.9 kPa (80 mm Hg) in 75% of patients.[35] The presence of underlying lung disease along with the size of pneumothorax predicts the degree of hypoxaemia.[35] Arterial Pao_2 was below 7.5 kPa (55 mm Hg) and $Paco_2$ above 6.9 kPa (50 mm Hg) in 16% of cases of secondary pneumothorax in the largest reported series.[36] Pulmonary function tests are weakly sensitive measures of the presence or size of pneumothorax and are not recommended.[8]

In both primary and secondary spontaneous pneumothorax the diagnosis is normally established by plain chest radiography. In general, expiratory radiographs add little and are not indicated as a routine investigation, even in the case of a suspected small apical pneumothorax.[37 38] When a pneumothorax is suspected but not confirmed by standard posteroanterior (PA) chest radiographs, lateral radiographs provide added information in up to 14% of cases.[39] The lateral decubitus radiograph is superior to the erect or supine chest radiograph and is felt to be as sensitive as CT scanning in pneumothorax detection.[40] The upright lateral or lateral decubitus radiograph is clinically helpful where findings on the upright PA radiograph are unclear. While such small pneumothoraces may not have much clinical relevance in patients without underlying lung disease, in patients with suspected secondary pneumothoraces, even small pneumothoraces may have significant implications and here lateral or lateral decubitus radiographs are probably valuable. In patients with severe bullous lung disease CT scanning will differentiate emphysematous bullae from pneumothoraces and save the patient an unnecessary and potentially dangerous aspiration.[41]

3 SIZE OF PNEUMOTHORAX

- **The previous classification of the size of a pneumothorax tends to underestimate its volume. In these new guidelines the size of a pneumothorax is divided into "small" or "large" depending on the presence of a visible rim of <2 cm or ⩾2 cm between the lung margin and the chest wall.**

The plain PA radiograph is a poor method of quantifying the size of a pneumothorax as it usually underestimates it. Exact methods of estimating size from PA chest radiographs are cumbersome and generally used only as a research tool.[42] The size of a pneumothorax, in terms of volume, is difficult to assess accurately from a chest radiograph which is a two dimensional image. In the 1993 guidelines[19] pneumothoraces were classified into three groups:

- "small": defined as a "small rim of air around the lung";
- "moderate": defined as lung "collapsed halfway towards the heart border"; and
- "complete": defined as "airless lung, separate from the diaphragm".

This attempt to quantify a pneumothorax tends to underestimate the volume of anything greater than the smallest of pneumothoraces.[1] Since the volume of a pneumothorax approximates to the ratio of the cube of the of the lung diameter to the hemithorax diameter, a pneumothorax of 1 cm on the PA chest radiograph occupies about 27% of the hemithorax volume if the lung is 9 cm in diameter and the hemithorax 10 cm: $(10^3 - 9^3)/10^3 = 27\%$. Similarly, a 2 cm radiographic pneumothorax occupies 49% of the hemithorax on the same basis (fig 3).

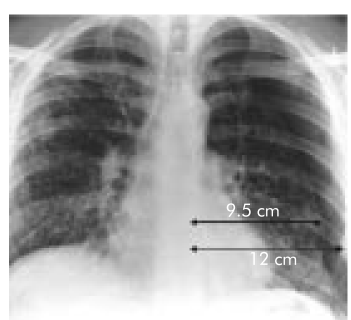
In view of the proximity of the lung surface to the chest wall in a pneumothorax of <1 cm, aspiration using a sharp needle may not be advisable. However, given that the actual volume of a 2 cm pneumothorax approximates to a 50% pneumothorax, this should be considered large in size and can be treated safely by aspiration when circumstances dictate. For the purposes of these new guidelines, "small" is therefore regarded as a pneumothorax of <2 cm and "large" as a pneumothorax of ⩾2 cm.

If accurate size estimates are required, CT scanning is the most robust approach.[43] Otherwise, it is only recommended for difficult cases such as patients in whom the lungs are obscured by overlying surgical emphysema, or to differentiate a pneumothorax from a suspected bulla in complex cystic lung disease.[44] The routine use of CT scans preoperatively in patients with pneumothorax and suspected emphysema or isolated bullae adds little to the plain PA chest radiograph from the point of view of management of the patient.[45]

4 TREATMENT OPTIONS FOR SPONTANEOUS PNEUMOTHORAX

4.1 Observation

- **Observation should be the treatment of choice for small closed pneumothoraces without significant breathlessness. [B]**
- **Patients with small (<2 cm) primary pneumothoraces not associated with breathlessness should be considered for discharge with early outpatient review. These patients should receive clear written advice to return in the event of worsening breathlessness. [B]**



1993:
Small secondary pneumothorax
Tx suggested: simple aspiration

2003:
Volume of pneumothorax $(12^3-9.5^3)/12^3 = 50\%$
Tx suggested: intercostal tube drainage

Figure 3 Quantitation of size of pneumothorax: 1993 versus 2003 guidelines.

- **If a patient with a pneumothorax is admitted overnight for observation, high flow (10 l/min) oxygen should be administered, with appropriate caution in patients with COPD who may be sensitive to higher concentrations of oxygen. [B]**
- **Breathless patients should not be left without intervention regardless of the size of the pneumothorax on a chest radiograph. [C]**

4.1.1 Primary pneumothoraces, minimal symptoms

Observation alone is advised for small, closed, mildly symptomatic spontaneous pneumothoraces.[21 30 46–48] 70–80% of pneumothoraces estimated at smaller than 15% have no persistent air leak and recurrence in those managed with observation alone is less than in patients treated with intercostal tube drainage.[48] Patients with small primary pneumothoraces and minimal symptoms do not require hospital admission, but it should be stressed before discharge that they should return directly to hospital in the event of developing breathlessness. Most patients in this group who fail this "treatment" and require intercostal tube drainage have secondary pneumothoraces.[48]

4.1.2 Secondary pneumothoraces, minimal symptoms

Observation alone is only recommended in patients with small secondary pneumothoraces of less than 1 cm depth or isolated apical pneumothoraces in asymptomatic patients. Hospitalisation is recommended in these cases. All other cases will require active intervention (aspiration or chest drain insertion, see later sections).

4.1.3 Symptomatic pneumothoraces, primary or secondary

Observation alone is inappropriate and active intervention is required. Marked breathlessness in a patient with a small (<2 cm) primary pneumothorax may herald tension pneumothorax.[48] If a patient is hospitalised for observation, supplemental high flow (10 l/min) oxygen should be given where feasible.[49] Inhalation of high concentrations of oxygen may reduce the total pressure of gases in pleural capillaries by reducing the partial pressure of nitrogen. This should increase the pressure gradient between the pleural capillaries and the pleural cavity, thereby increasing absorption of air from the pleural cavity. The rate of resolution/reabsorption of spontaneous pneumothoraces is 1.25–1.8% of the volume of hemithorax every 24 hours.[47 50] In a group of 11 patients with pneumothoraces ranging in size from 16% to 100%, the mean rate of re-expansion was 1.8% per day and full re-expansion occurred at a mean of 3.2 weeks.[47] A 15% pneumothorax would therefore take 8–12 days to resolve fully. The addition of high flow oxygen therapy has been shown to result in a fourfold increase in the rate of pneumothorax reabsorption during periods of oxygen supplementation.[49]

4.2 Simple aspiration

- **Simple aspiration is recommended as first line treatment for all primary pneumothoraces requiring intervention. [A]**
- **Simple aspiration is less likely to succeed in secondary pneumothoraces and, in this situation, is only recommended as an initial treatment in small (<2 cm) pneumothoraces in minimally breathless patients under the age of 50 years. [B]**
- **Patients with secondary pneumothoraces treated successfully with simple aspiration should be admitted to hospital and observed for at least 24 hours before discharge. [C]**

The 1993 BTS guidelines[19] recommended simple aspiration as first line treatment in all primary pneumothoraces where there is complete collapse of the lung, and in smaller primary pneumothoraces in which patients complain of significant breathlessness. Simple aspiration was also recommended as initial treatment in secondary pneumothoraces where there is moderate or complete collapse of the lung and in smaller secondary pneumothoraces where significant breathlessness is present. Small was defined as a "small rim of air around the lung", moderate as "lung collapsed halfway towards the heart border", and complete as "airless lung, separate from the diaphragm".

A study describing treatment practices for pneumothoraces after the 1993 guidelines showed that only 17 of 43 decisions to aspirate pneumothoraces by A&E staff, perhaps because of unfamiliarity with the technique, and nine of 26 similar decisions made by medical staff seemed appropriate.[20] A similar study undertaken in Scotland and completed before the publication of the 1993 guidelines reported that only three of 38 spontaneous pneumothoraces (one primary, two secondary) were treated initially by aspiration alone and all three were successful.[21] It would seem, therefore, that many medical staff are unaware of the guidelines in this respect, or are unwilling or unable to aspirate.

Successful re-expansion of the lung is less likely after simple aspiration in secondary pneumothorax (33–67%) than in primary (59–83%).[51–53] However, several larger series which used this technique found that 59–73% of all pneumothoraces requiring intervention could be successfully aspirated.[51 52 54–56] Successful aspiration in these series depended on age (under 50 years: 70–81% success, over 50 years: 19–31% success), the presence of chronic lung disease (27–67% success), and the size of the pneumothorax (<3 l aspirated: 89% success, >3 l: no success; >50% on chest film: 62% success, <50% on chest film: 77% success). In a prospective randomised trial to compare simple aspiration and tube drainage of pneumothoraces, Andrivert and colleagues[55] found a 20% recurrence rate at 3 months after simple aspiration of primary pneumothoraces and a 28% recurrence rate after tube drainage demonstrating that simple aspiration is no less effective from the point of view of recurrence than the more invasive intercostal tube drainage. In a more recent randomised controlled trial Noppen and coworkers[53] showed that simple aspiration was as successful in treating first primary pneumothoraces as immediate intercostal tube drainage (59% versus 63%). Patients treated with simple aspiration were less likely to be hospitalised and less likely to suffer a recurrence of the pneumothorax over the next 12 months. Harvey and Prescott,[56] on behalf of the British Thoracic Society, confirmed that simple aspiration of primary pneumothoraces is as effective as tube drainage when recurrence of pneumothorax at 12 months was taken as an end point. Further advantages of simple aspiration over intercostal tube drainage are a reduction in total pain scores during hospitalisation and shorter hospital stays.[56] In centres where the experience and equipment is available, consideration should be give to using small bore catheter aspiration kits (CASP, see below) to aspirate pneumothoraces as the catheter may be left in place until full re-expansion of the lung is confirmed. Otherwise, repeat aspiration or connection to an underwater seal system may be facilitated through these indwelling small bore catheters.

Large secondary pneumothoraces (⩾2 cm), particularly in patients over the age of 50, should be considered a high risk of failure for simple aspiration and recurrence and therefore tube drainage is recommended as appropriate initial treatment. If simple aspiration is considered in patients with secondary pneumothoraces, admission for observation for at least 24 hours should be undertaken, with prompt progression to tube drainage if needed. Active treatment of the underlying lung disorder will also be necessary.

4.2.1 Repeat aspiration and catheter aspiration of simple pneumothorax

- **Repeated aspiration is reasonable for primary pneumothorax when the first aspiration has been unsuccessful (i.e. patient still symptomatic) and a volume of <2.5 l has been aspirated on the first attempt. [B]**
- **Catheter aspiration of pneumothorax (CASP) can be used where the equipment and experience is available. [B]**
- **Catheter aspiration kits with an integral one way valve system may reduce the need for repeat aspiration. [C]**

Failure to re-expand a primary pneumothorax with aspiration can be successfully corrected by a second aspiration in over one third of cases, particularly where the initial attempt failed because of a kinked or displaced catheter.[51] Despite this, the tendency is to treat aspiration failures with tube drainage.[20 51 52] A second attempt at simple aspiration of the pneumothorax should be considered unless >2.5 l was aspirated during the unsuccessful first attempt.[56] Catheter aspiration of simple pneumothorax (CASP) involves a small (8 F) catheter being passed over a guidewire into the pleural space. A three way stopcock is attached and air may be aspirated via a 50 ml syringe. This controls up to 59% of all pneumothoraces. Addition of a Heimlich valve and suction may improve success rates further.[57–59]

4.3 Intercostal tube drainage

- **If simple aspiration or catheter aspiration drainage of any pneumothorax is unsuccessful in controlling symptoms, then an intercostal tube should be inserted. [B]**
- **Intercostal tube drainage is recommended in secondary pneumothorax except in patients who are not breathless and have a very small (<1 cm or apical) pneumothorax. [B]**
- **A bubbling chest tube should never be clamped. [B]**
- **A chest tube which is not bubbling should not usually be clamped. [B]**
- **If a chest tube for pneumothorax is clamped, this should be under the supervision of a respiratory physician or thoracic surgeon, the patient should be managed in a specialist ward with experienced nursing staff, and the patient should not leave the ward environment. [C]**
- **If a patient with a clamped drain becomes breathless or develops subcutaneous emphysema, the drain must be immediately unclamped and medical advice sought. [C]**

Underwater seal drainage using a chest tube was introduced in 1875.[60] Widespread closed tube drainage was first adopted during the 1917 influenza epidemic.[61] Intercostal tube drainage or underwater seal drainage in its modern form has been in use since 1916 when Kenyon[62] described a "siphon" method of draining traumatic haemothorax. This treatment, despite being extremely effective, has many potential disadvantages ranging from chest and abdominal visceral trauma from sharp trocars in the hands of inexperienced operators[63] to the bulkiness of the underwater seal bottle system which must be kept upright.

Likewise it may be hazardous to clamp a chest drain that is still bubbling, thereby potentially converting simple pneumothoraces into life threatening tension pneumothoraces.[64] Such instances are anecdotal, and there is no evidence of which we are aware that clamping the tube improves success rates or prevents recurrence. Almost identical success rates have been recorded for the maintenance of full re-expansion of the lung after 24 hours whether the tube is clamped or not before removal.[80] However, many experienced physicians still support the use of clamping of chest drains before their removal to detect small air leaks not immediately obvious at the bedside. By clamping the chest drain for several hours and performing a chest radiograph, a minor or intermittent air leak may be detected, potentially avoiding the need for chest tube reinsertion. In the ACCP Delphi consensus statement[65] about half the consensus group supported clamping and half did not, and this seems similar to the UK spread of opinion. Drain clamping is therefore not generally recommended for safety reasons, but is acceptable under the supervision of nursing staff who are trained in the management of chest drains and who have instructions to unclamp the chest drain in the event of any clinical deterioration. Patients with a clamped chest drain inserted for pneumothorax should not leave the specialist ward area.

Despite these risks, tube drainage remains an effective treatment for pneumothorax although it is not proven that tube drainage should be performed as the initial treatment in any pneumothorax. Simple aspiration should be considered as the primary treatment for all primary pneumothoraces requiring intervention but not considered to be under tension. In secondary pneumothoraces in patients over 50 years with pneumothorax >50%, primary failure rates for aspiration are estimated at >50%.[51 52 66] Age alone is a strong predictor of failure of simple aspiration (>50 years, success 27–67%),[51 52] although in those over the age of 50 years with no evidence of pre-existing lung disease there is no evidence that tube drainage should be recommended before simple aspiration as primary treatment.

Analgesic use during the insertion of intercostal tubes remains poorly studied. The injection of intrapleural local anaesthetic (20–25 ml = 200–250 mg, 1% lignocaine) given as a bolus and at eight hourly intervals as necessary after the insertion of the drain significantly and safely reduced pain scores without affecting blood gas measurements, either with or without chemical pleurodesis. There are no data detailing the incidence of pleural infection with this technique.[67 68] Chest tubes frequently (59%) end up in fissures,[69] but these tubes seem to retain their effectiveness. Step by step guidelines to chest drain insertion are described elsewhere in these guidelines (page ii53).

4.3.1 Complications of intercostal tube drainage

The complications of intercostal tube drainage include penetration of the major organs such as lung, stomach, spleen, liver, heart and great vessels, and are potentially fatal.[63 70–73] These complications occur more commonly when a sharp metal trocar is inappropriately applied during the procedure.[63 72 73]

In the largest series reviewing complications of tube drainage in recent times, Chan and colleagues[74] identified complications in 18% of chest drain insertions for all indications; 64% of these chest tubes (n=373) were inserted for treatment of pneumothorax. However, 15% of the "complications" identified involved failure of resolution of the pneumothorax and only 4% involved aberrant tube placement. Notably, complications related to tube placement occurred most commonly on medical wards. CT assessment suggests a higher rate of incorrect tube placement. Baldt and colleagues[75] identified 3% of tubes placed extrathoracically and 6% placed within the lung during the treatment of pneumothoraces. This highlights the need for correct training in chest tube placement. In some circumstances, thoracic CT scanning is valuable for assessing chest tube position—for example, when misplacement is suspected but not confirmed on a plain radiograph.[75]

Pleural infection is another complication of intercostal tube drainage. The rate of empyema after chest tube insertion has

been estimated as 1%.[74] Other series have reported an incidence of up to 6% of chest tube related empyema in trauma cases and suggested that the administration of prophylactic antibiotics should be considered, particularly where a prolonged period of chest tube drainage might be anticipated.[76 77] This highlights the need for full aseptic technique in the insertion or manipulation of any chest drainage system.

Finally, surgical emphysema is a well recognised complication of intercostal tube drainage.[78] This is generally of cosmetic importance only, subsiding after a few days. The development of surgical emphysema associated with pneumothorax involves an air filled space, not formerly in communication with the subcutaneous tissue, being brought into communication with the subcutaneous tissues. This may occur in the presence of a malpositioned, kinked, blocked, or clamped tube. Likewise, a small tube in the presence of a very large leak may potentially cause surgical emphysema. Occasionally, the resulting acute airway obstruction or thoracic compression may lead to respiratory compromise.[78 79] The treatment is usually conservative but, in life threatening situations, tracheostomy, skin incision decompression, and insertion of large bore modified subcutaneous chest drains have all been used.[78]

4.3.2 Size of tube

- **There is no evidence that large tubes (20–24 F) are any better than small tubes (10–14 F) in the management of pneumothoraces. The initial use of large (20–24 F) intercostal tubes is not recommended, although it may become necessary to replace a small chest tube with a larger one if there is a persistent air leak. [B]**

Although one study suggested that success rates for the treatment of pneumothoraces with small chest tubes (13 F) were poor and that larger sized catheters should be used,[80] subsequent studies have not confirmed this and suggest that smaller calibre chest tubes are just as effective.[81–84] Primary success rates of 84–97% were recorded in these studies using drains of 7–9 F gauge. Recent technical developments have allowed the addition of a Heimlich flutter valve to small tubes as well as to larger bore tubes.

Factors which might predispose to small tube failure, thus favouring the choice of a larger tube, would be the presence of pleural fluid and the presence of a large air leak which exceeds the capacity of the smaller tubes.[82] The use of an indwelling small lumen Teflon catheter (2 mm) inserted "over needle and guidewire" attached to a flutter valve after partial aspiration with a 60 ml syringe proved successful in 27 of 28 patients with a mean drainage time of 48 hours.[59] Using a small calibre chest drain system, the median duration of drainage ranged from 2 to 4 days, which compares very favourably with larger intercostal tube drainage systems.[59 82 83] Difficulties with tube blockage were not encountered in any of these studies. Chemical pleurodesis is still possible through smaller tubes including indwelling catheter systems.

If the decision is made to insert a chest drain, small (10–14 F) systems should be used initially. The use of catheter over guidewire systems (Seldinger technique) may prove to be as safe and effective as small calibre tubes, although they are more expensive. They are being used with increasing frequency, but further evidence is required before they can be recommended for initial use.

4.4 Referral to respiratory specialists

- **Pneumothoraces which fail to respond within 48 hours to treatment should be referred to a respiratory physician. [C]**

Failure of a pneumothorax to re-expand or a persistent air leak exceeding 48 hours duration should prompt referral to a respiratory physician. Such patients may require sustained chest drainage with complex drain management (suction, chest drain repositioning) and thoracic surgery decisions. These issues will be better managed by physicians with specific training and experience in these problems and established relationships with a thoracic surgeon. Drain management is also best delivered by nurses with substantial experience in this area.

4.4.1 Chest drain suction

- **Suction to an intercostal tube should not be applied directly after tube insertion, but can be added after 48 hours for persistent air leak or failure of a pneumothorax to re-expand. [B]**
- **High volume, low pressure (–10 to –20 cm H_2O) suction systems are recommended. [C]**
- **Patients requiring suction should only be managed on lung units where there is specialist medical and nursing experience. [C]**

There is no evidence to support the routine initial use of suction applied to chest drain systems in the treatment of spontaneous pneumothorax.[80 85] A persistent air leak, with or without incomplete re-expansion of the pneumothorax on a chest radiograph, is the usual reason for applying suction to an intercostal tube system. A persistent air leak is usually arbitrarily defined as a continued air bubbling through an intercostal tube 48 hours after insertion. Mathur and colleagues[86] retrospectively reviewed 142 cases of spontaneous pneumothorax requiring chest drain insertion. The median time to resolution was 8 days (19 days in those with underlying lung disease), which was not related to the initial size of the pneumothorax. Most of the patients (30/43) with a persistent air leak had suction applied, but without standardisation of the degree of suction or of the point of initiation (the first 4 days in the majority). Normal intrapleural pressures are –8 cm H_2O during inspiration and –3.4 cm H_2O during expiration. During intercostal tube drainage various factors influence the amount of suction applied to the pleural space.[63 87] It has been suggested that, because the magnitude of these physiological factors varies, it is desirable to apply –10 to –20 cm H_2O suction to all pneumothoraces which are slow to re-expand, and the system used should have the capacity to increase the suction with an air flow volume of 15–20 l/min.[88] Over 40 years ago Roe[89] stressed the importance of high volume vacuums to drain the pleural space during pneumothoraces. The use of high pressure, high volume suction is not, however, recommended because of the ease with which it can generate high air flow suction which may lead to air stealing, hypoxaemia, or the perpetuation of persistent air leaks.[90] Likewise, high pressure, low volume systems should be avoided.[64] High volume, low pressure systems such as a Vernon-Thompson pump or wall suction with an adaptor to reduce pressure are recommended. Unfortunately, due to the lack of more recent randomised controlled trials examining the role of suction with intercostal tube systems, evidence based recommendations cannot be applied. The best practice from previous studies to date, as above, suggests that suction should be applied after 48 hours, but that surgical referral for a persistent air leak in those without pre-existing lung disease should be made at 5–7 days. Significantly, earlier referral (2–4 days) should be considered in those with underlying disease, a large persistent air leak, or failure of the lung to re-expand.[91–93] If suction is to be applied to a chest drain, it is recommended that the patient should be situated in an area where specialist nursing experience is available.

The addition of suction too early after the insertion of a chest tube, particularly in the case of a primary pneumothorax which may have been present for a few days, may precipitate re-expansion pulmonary oedema (RPO) and is

contraindicated. RPO is probably caused by the increased permeability of capillaries damaged during a pneumothorax. This becomes manifest as oedema during re-expansion due to further mechanical stresses applied to the already "leaky" capillaries.[94] Clinically, these patients manifest symptoms of coughing and breathlessness or chest tightness after insertion of the chest tube. In those whose symptoms persist, a repeat chest radiograph after 24 hours will often show pulmonary oedema in the treated lung, although pulmonary oedema may also develop in the contralateral lung.[95] The incidence of RPO may be up to 14% and is higher in those with larger primary pneumothoraces and in younger patients (<30 years), although in most cases RPO does not progress beyond a radiological phenomenon.[96] However, the clinical relevance of RPO must not be understated as the outcome has been reported as fatal in 20% of 53 reported cases who developed a clinical deterioration as part of an RPO syndrome in one series.[95] Particular caution should therefore be exercised in treating young patients with large pneumothoraces and suction should not be used immediately in the treatment of a spontaneous pneumothorax. Even when employed later and it is suspected that the pneumothorax has been present for a considerable period of time, the potential development of RPO should be considered.[96]

4.4.2 Chemical pleurodesis

- **Chemical pleurodesis can control difficult or recurrent pneumothorax [A] but should only be attempted if the patient is either unwilling or unable to undergo surgery. [B]**
- **Medical pleurodesis for pneumothorax should be performed by a respiratory specialist. [C]**

Chemical pleurodesis has generally been advocated by chest physicians experienced in thoracoscopy. The instillation of substances into the pleural space should lead to an aseptic inflammation with dense adhesions, leading ultimately to pleural symphysis. There is a high rate of recurrence of primary and secondary pneumothoraces,[14] and efforts to reduce these rates by instillation of various sclerosants—either via chest drains or by surgical means—are regularly undertaken without clear guidelines to direct physicians in their use. In the majority of cases, when appropriate, the prevention of further pneumothoraces should be undertaken by surgical means. The rate of recurrence of pneumothoraces after surgical intervention either by thoracotomy or VATS, with or without surgical pleurodesis, is far less than after medical pleurodesis.[36 97–99] A small number of individuals are either too frail or are unwilling to undergo any definitive surgical treatment to prevent recurrence of their pneumothoraces and, in these instances, medical chemical pleurodesis may be appropriate.

During the last decade many sclerosing agents have been studied.[36 97 100–103] Tetracycline is recommended as the first line sclerosant therapy in both primary and secondary pneumothoraces. It was initially proposed as it proved to be the most effective sclerosant in animal models.[101 104 105] Recently, parenteral tetracycline for pleurodesis has become more difficult to obtain due to problems with the manufacturing process. The parenteral preparation is currently available in Germany and may be imported via international wholesalers. These suppliers state that supplies are expected to remain available for the foreseeable future. Minocycline and doxycycline have been shown to be reasonable alternatives as sclerosants in animal models.[104 105]

The rate of recurrence of pneumothorax is the primary indicator of success for any sclerosant. Although tetracycline has been shown significantly to reduce the incidence of early recurrence, the incidence of late recurrence is 10–20% which is unacceptably high compared with surgical methods of pleurodesis.[97 99 103] Large randomised controlled studies comparing the use of tetracycline as a sclerosant with standard management in primary pneumothorax are needed to determine whether or not tetracycline should be used after treatment of a first uncomplicated primary pneumothorax to prevent recurrence. Tetracycline can, however, be recommended for recurrent primary pneumothorax and secondary pneumothorax when surgery is not an option, and talc may be used on the grounds that it is the most effective agent in malignant effusion. There is conflicting evidence as to whether tetracycline is effective for the treatment of fully expanded pneumothorax with persistent air leak.[36 106 107] The largest of these studies, the Veterans Administration Study, did not support the use of intrapleural tetracycline to facilitate the closure of a persistent air leak.[36] Macoviak and colleagues[107] suggest that intrapleural tetracycline can facilitate the closure of a persistent air leak provided that the lung can be kept expanded so that symphysis can occur. Likewise, there is conflicting evidence as to whether intrapleural tetracycline shortens the length of stay in hospital with pneumothorax.[36 97 103]

The dosage of intrapleural tetracycline requires clarification. Almind *et al*[97] found a reduction in the incidence of recurrence in a group receiving 500 mg tetracyline via chest drains compared with those treated by tube drainage alone. This reduction was not significant. The Veterans Administration Study,[36] which used 1500 mg tetracycline, showed a significant reduction in the incidence of recurrence of pneumothorax without significant extra morbidity. This dose of intrapleural tetracycline is therefore recommended as the standard dose for medical pleurodesis. While pain was reported more frequently in the group treated with tetracycline at a dose of 1500 mg,[36] others have reported no increase in pain with tetracycline at a dose of 500 mg provided adequate analgesia is given.[97] Adequate analgesia may be achieved with administration of intrapleural local anaesthesia. Standard doses (200 mg (20 ml) 1% lignocaine) are significantly less effective than larger doses (250 mg (25 ml) 1% lignocaine). The higher doses have been shown to increase the number of pain free episodes from 10% to 70% with no appreciable toxicity.[68]

Medical and surgical pleurodesis using talc remain effective alternatives to tetracycline pleurodesis. There are no controlled trials comparing talc and tetracycline as sclerosants in the treatment of pneumothorax. The issue of talc pleurodesis will be dealt with later in the surgical section of this review as most trials using talc tend to focus on surgical talc pleurodesis.

Since medical pleurodesis is recognised to be "second best" care and its use will imply a "difficult" case, it is recommended that medical pleurodesis be undertaken only by respiratory specialists or thoracic surgeons.

4.5 Referral to thoracic surgeons

- **In cases of persistent air leak or failure of the lung to re-expand, the managing respiratory specialist should seek an early (3–5 days) thoracic surgical opinion. [C]**
- **Open thoracotomy and pleurectomy remains the procedure with the lowest recurrence rate for difficult or recurrent pneumothoraces. Minimally invasive procedures, thoracoscopy (VATS), pleural abrasion, and surgical talc pleurodesis are all effective alternative strategies.**

The timing of surgical intervention for pneumothorax has recently been challenged and remains contentious. There is no evidence based justification for the arbitrary but widely advocated cut off point of 5 days for surgery for a persistent air leak.[48] Chee and colleagues[108] showed that 100% of primary pneumothoraces treated by tube drainage with persistent air leaks for more than 7 days had resolved their air leaks by 14 days and 79% of those with secondary pneumothoraces and

persistent air leaks had resolved their air leaks by 14 days with no mortality. However, considering the efficacy and relatively low levels of morbidity and recurrence associated with surgery for pneumothorax,[109–112] earlier surgical intervention has been advocated for persistent air leak or failure of re-expansion, particularly in cases of secondary pneumothorax.[92 113] Several authors have recommended operative referral/intervention as early as 3 days for a persistent air leak. However, these studies were not controlled.[91 93] Despite the reduction in the incidence of late recurrence of pneumothorax in many of these studies, surgical referral for a persistent air leak in a first primary pneumothorax within the first 4–5 days is not supported by the literature. However, best practice suggests that protracted chest tube drainage is not in the patient's interest. It is therefore recommended that patients with difficult pneumothoraces should receive care from a respiratory physician and that a thoracic surgical opinion will be an early part of management.

According to the statistical and perceived risk of recurrence, accepted indications for operative intervention are as follows:

- Second ipsilateral pneumothorax
- First contralateral pneumothorax
- Bilateral spontaneous pneumothorax
- Persistent air leak (>5–7 days of tube drainage; air leak or failure to completely re-expand)
- Spontaneous haemothorax
- Professions at risk (e.g. pilots, divers)[108 110 114–116]

4.5.1 Surgical strategies

There are two objectives in the surgical management of a pneumothorax. The first widely accepted objective is resection of blebs or the suture of apical perforations to treat the underlying defect. The second objective is to create a pleural symphysis to prevent recurrences. There is debate between those who favour surgical pleurodesis or pleural abrasion versus those who favour partial or total pleurectomy as a definitive treatment to prevent recurrence of pneumothorax,[109 117 118] although a relatively recent comprehensive review of this area suggests a slight advantage of pleurectomy over pleural abrasion with a recurrence rate of 0.4% after pleurectomy (n=752) and 2.3% after pleural abrasion (n=301).[109] Operative techniques have tended towards minimally invasive procedures over the last few years. In order to be considered effective, these techniques should yield results comparable to the "gold standard" open thoracotomy procedure—that is, the operative morbidity should be less than 15% and the pneumothorax recurrence rate should be less than 1%.[37 99 112]

Open thoracotomy

In 1941 Tyson and Crandall[119] described pleural abrasion as a treatment for pneumothorax and in 1956 Gaensler[117] introduced parietal pleurectomy for recurrent pneumothorax. This procedure produces uniform adhesions between the pleura and the chest wall. Both of these techniques are designed to obliterate the pleural space by creating symphysis between the two pleural layers or between the visceral pleura and subpleural plane, in the case of parietal pleurectomy. In order to prevent recurrence, however, an appropriate closure at the site of the pleural air leak is essential either by cauterisation, ligation, or suture of accompanying blebs.[116] Open thoracotomy yields the lowest postoperative recurrence results. Bulla ligation/excision, thoracotomy with pleural abrasion, and either apical or total parietal pleurectomy all have failure rates under 0.5%.[48 110] Morbidity from thoracotomy for pneumothorax has an overall incidence of 3.7%, mostly in the form of sputum retention and postoperative infection.[110] Open thoracotomy is generally performed using single lung ventilation, a limited posterolateral thoracotomy allowing parietal pleurectomy, excision, or stapling of bullae or pleural abrasion.[120] Isolated lung ventilation during open thoracotomy facilitates full visualisation of the visceral pleura. This may not be possible during a VATS procedure, increasing the risk of missing a leaking bulla.[121–123] Open thoracotomy may be associated with increased postoperative respiratory dysfunction and hospital stay compared with VATS procedures.[120] It is suggested that the success rates with the open procedure are higher.[124] Thus, surgical authorities suggest open thoracotomy in patients with secondary pneumothoraces who may have extensive pleural disease requiring more extensive pleurectomy, subpleural bullectomy, or pleural abrasion.[110 114 125]

Surgical chemical pleurodesis

- **Surgical chemical pleurodesis is best achieved with 5 g sterile talc. Side effects such as ARDS and empyema are reported but rare. [A]**

The use of talc pleurodesis is now a subject of renewed interest because of the potential unavailability of tetracycline, its low cost, and a record of successful pleurodesis (85–92%) that is similar to alternative thoracoscopic techniques for complicated pneumothorax.[99 114 126 127] While talc slurry inserted under medical supervision via intercostal tube drainage tends to be less favoured than thoracoscopic talc poudrage, both methods have been shown to be effective. The overall success rate for talc pleurodesis reviewed by meta-analysis is 91%.[126] Surgical pleurodesis with tetracycline is not generally felt to be a satisfactory alternative, with recurrence rates of 16% in a series of 390 patients who underwent surgical pleurodesis using tetracycline.[98] There are no controlled trials comparing pain during talc pleurodesis with that using other agents, although it is suggested that talc pleurodesis is no more difficult or painful a procedure than tetracycline pleurodesis.[128–132] Dosages of talc ranging from 2 g to 10 g have been used, but the suggestion that higher dosages are more effective has not been established by controlled trials. On the basis of a meta-analysis of uncontrolled data, 5 g talc by VATS is recommended with a success rate of 87%, which is very close to the success rates using more extensive operative approaches.[126] Side effects reported with talc pleurodesis include five cases of adult respiratory distress syndrome (ARDS), although the risk of ARDS may be related to the size of talc particles used[133]; empyema, although this is rare when properly sterilised talc is used[126 134 135]; pneumonia; and respiratory failure.[134] In view of these potential side effects, standard first line usage of talc poudrage or talc slurry pleurodesis should be approached with caution since surgery not dependent on introducing a foreign agent is usually an option. Lower dosages of 2–5 g should be used until dosage schedules and effectiveness have been clarified. Long term safety does not appear to be an issue if asbestos-free talc is used. The success rates with talc poudrage and talc slurry pleurodesis are similar, so either approach can be recommended. Because of the relatively high failure rates of over 9% with talc pleurodesis compared with surgical pleural stripping procedures, talc pleurodesis should not be considered as initial treatment for primary spontaneous pneumothorax requiring surgical intervention. In those patients who are either unwilling or too unwell to undergo general anaesthesia, medical pleurodesis with either tetracycline or talc (via an intercostal tube) is recommended.

Transaxillary minithoracotomy

Becker and Munro[136] pioneered this technique in the 1970s. The procedure is considered a minimally invasive procedure. The incision in the axillary margin measures 5–6 cm. Apical pleurectomy or abrasion may be performed and the apex carefully inspected for pleural blebs or bullae which may be stapled. The largest series examining this technique reported a mean hospital stay of 6 days, a recurrence rate of 0.4%, and a complication rate of 10%, most of which were minor.[125] These results make this procedure a realistic alternative to open

thoracotomy for the treatment of complicated spontaneous pneumothorax.

Video assisted thoracoscopic surgery (VATS)

The evaluation of VATS for spontaneous pneumothorax is limited by the small number of randomised trials comparing it with alternative surgical approaches. To date, there have only been two randomised studies which have attempted to define the role of VATS in the treatment of spontaneous pneumothorax.[120 137] In a comprehensive review, Massard and colleagues[99] have suggested that the impression that VATS is superior to open procedures in terms of morbidity, time in hospital, and cost may not be wholly correct. Minimally invasive surgery may have a complication rate similar to open procedures at about 8–10%.[120 122 138] Recurrence rates of pneumothorax after VATS are 5–10%,[114 127] which are higher than the 1% rates reported after open procedures.[110] While bullectomy, pleurectomy, pleural abrasion, and surgical pleurodesis have all been shown to have reasonable success rates when carried out thoracoscopically,[120 122 128 139–141] there are concerns associated with VATS performed under local anaesthetic supplemented by nitrous oxide inhalation. These arise from the inability to obtain isolated single lung ventilation and include difficulties in inspecting the entire visceral pleural surface, increasing the risk of missing a leaking bleb or bulla.[123 142] It is also suggested that a less intense pleural inflammatory reaction is induced by VATS procedures leading to a less effective pleurodesis.[143] Several authors suggest that VATS offers significant advantages over open thoracotomy including a shorter postoperative hospital stay,[114 120 127 138 142] significantly less postoperative pain,[120 125 143 144] and better pulmonary gas exchange in the postoperative period.[145] However, Kim and colleagues in their randomised controlled trial did not confirm a shorter postoperative stay in the VATS groups.[137]

Further randomised trials comparing VATS with transaxillary and open thoracotomies are required and, until these data are available, VATS cannot be considered to be established as being superior to thoracotomy.[144] Waller and colleagues[146] suggested that, while VATS may be the preferred surgical procedure for young fit people with complicated or recurrent primary pneumothoraces, it is less reliable in cases of secondary pneumothorax. In cases of secondary pneumothorax, open thoracotomy and repair is still the recommended approach and VATS procedures should be reserved for those who might not tolerate an open procedure because of poor lung function.

4.6 Discharge and follow up

- **Patients discharged without intervention should avoid air travel until a chest radiograph has confirmed resolution of the pneumothorax. [C]**
- **Diving should be permanently avoided after a pneumothorax, unless the patient has had bilateral surgical pleurectomy. [C]**
- **Primary pneumothorax patients treated successfully by simple aspiration should be observed to ensure clinical stability before discharge. Secondary pneumothorax patients who are successfully treated with simple aspiration should be admitted for 24 hours before discharge to ensure no recurrence. [C]**

Patients with spontaneous pneumothoraces who are discharged without active intervention should be advised to return for a follow up chest radiograph after 2 weeks. These patients should be cautioned against flying until a follow up chest radiograph confirms full resolution of the pneumothorax. Commercial airlines currently arbitrarily advise that there should be a 6 week interval between having a pneumothorax and travelling by air. A recent chest radiograph should confirm resolution of the pneumothorax. A patient with a current closed pneumothorax should not travel on a commercial flight. There is no evidence that air travel precipitates recurrence of a pneumothorax, but recurrence during a flight may have serious repercussions. The BTS Air Travel Working Party stress that patients may travel safely 6 weeks after a definitive surgical procedure or resolution of the pneumothorax on the chest radiograph. Otherwise, there is still a significant risk of recurrence for up to 1 year, depending on whether the patient has underlying lung disease or not. Patients, particularly those who have suffered a secondary spontaneous pneumothorax, may decide to avoid the risk by avoiding flying for a year in the absence of a definitive surgical procedure.[147] After a pneumothorax, diving should be discouraged permanently unless a very secure definitive prevention strategy such as surgical pleurectomy has been performed.[148] The BTS guidelines on respiratory aspects of fitness for diving[149] deal with this in greater detail.

Patients with primary pneumothorax treated successfully by simple aspiration should be observed to ensure clinical stability before discharge. The few patients with secondary pneumothorax who are successfully treated with simple aspiration should be admitted at least overnight and preferably for 24 hours before discharge to ensure no recurrence. The mortality rate associated with secondary pneumothorax is 10%, and many of these patients die after the pneumothorax has resolved.[18 32] Most patients with secondary pneumothorax will require a more protracted admission, including treatment of their underlying lung disorder.[32] All patients discharged after active treatment or otherwise should be given verbal and written advice to return to the Accident and Emergency department immediately should they develop further breathlessness.

5 PNEUMOTHORAX AND AIDS

- **Early and aggressive treatment of pneumothoraces in HIV patients, incorporating intercostal tube drainage and early surgical referral, is recommended. [B]**

There is evidence that the clinical spectrum of spontaneous pneumothorax is shifting away from the predominant subpleural bleb disease as emphasised by most reports since Kjaergard.[3] There are several reports that up to 25% of spontaneous pneumothoraces in large urban settings with a high prevalence of HIV infection are AIDS related[31 32 150]; 2–5% of AIDS patients will develop a pneumothorax.[151–153] *Pneumocystis carinii* infection should be considered as the most likely aetiology in any HIV positive patient who develops a pneumothorax, although the administration of aerosolised pentamidine has also been suggested as an independent risk factor.[151] *Pneumocystis carinii* pneumonia (PCP) is associated with a severe form of necrotising alveolitis in which the subpleural pulmonary parenchyma is replaced by necrotic thin walled cysts and pneumatoceles.[154 155] AIDS related spontaneous pneumothorax is complicated by the refractory nature of air leaks which tend to occur with the necrotising subpleural pneumonitis of PCP infection.[156] Such is the relationship between AIDS related pneumothorax and the presence of *P carinii* that the occurrence of pneumothorax in AIDS patients is considered an indicator of treatment for active *P carinii* infection.[151] AIDS related spontaneous pneumothorax carries a higher hospital mortality, a higher incidence of bilateral (40%) and recurrent pneumothoraces, and more prolonged air leaks.[157] Treatment failures may also reflect the degree of immunocompromise of the impaired host as reflected by the CD4 counts.[157] It has also been suggested that systemic corticosteroids used to treat PCP may increase the risk of morbidity from AIDS related pneumothorax.[158] Because of the high rate of primary treatment failures and associated short survival times reported for such patients,[159 160] early and

aggressive treatment of AIDS related spontaneous pneumothorax—incorporating early tube drainage and talc pleurodesis, early VATS assisted talc poudrage, unilateral or bilateral pleurectomy—is recommended.[150 152 157 158 161 162]

6 PNEUMOTHORAX AND CYSTIC FIBROSIS

- **Early and aggressive treatment of pneumothoraces in cystic fibrosis is recommended. [C]**
- **Surgical intervention should be considered after the first episode, provided the patient is fit for the procedure. [C]**

The treatment of pneumothorax for patients with cystic fibrosis (CF) is similar to that for non-CF patients. A pneumothorax is associated with more severe disease and can be life threatening. Median survival after pneumothorax in patients with CF is 30 months and the occurrence reflects the severity of the underlying disease rather than being an independent risk factor.[163] Contralateral pneumothoraces occur in up to 40% of patients.[163 164] A small pneumothorax without symptoms can be observed or aspirated. Larger pneumothoraces require treatment with intercostal tube drainage. The leak is usually from the upper lobes and it is important to site the tube in the correct place. The collapsed lung can be stiff and take a long time to re-expand. It is important to commence intravenous antibiotics at the same time to prevent sputum retention, which can delay re-expansion of the collapsed lung. Pleurectomy, pleural abrasion, and talc pleurodesis all have markedly lower reported recurrence rates than observation or tube thoracostomy alone, which has an unacceptably high recurrence rate of 50%.[165–167] Partial pleurectomy has a success rate of 95% with little reduction in pulmonary function associated with surgery, and it is generally felt to be the treatment of choice in CF patients with recurrent pneumothoraces who are fit to undergo surgery.[163] In those patients who are too ill to undergo surgery, it can take 2–3 weeks for the lung to re-expand with intubation and suction. In this group, talc instillation or repeated instillation of the patient's own blood are effective alternatives.[163] Although not an absolute contraindication to transplantation, sclerosants can make transplantation more difficult. It takes longer to remove the lungs, prolonging the ischaemic time for the donor lungs, and is associated with excessive bleeding.[168]

7 TENSION PNEUMOTHORAX

- **If tension pneumothorax is present, a cannula of adequate length should be promptly inserted into the second intercostal space in the mid clavicular line and left in place until a functioning intercostal tube can be positioned. [B]**

Tension pneumothorax occurs when the intrapleural pressure exceeds the atmospheric pressure throughout inspiration as well as expiration. It is thought to result from the operation of a one way valve system, drawing air into the pleural space during inspiration and not allowing it out during expiration. The development of tension pneumothorax is often, but not always, heralded by a sudden deterioration in the cardiopulmonary status of the patient related to impaired venous return, reduced cardiac output, and hypoxaemia.[169 170] The development of tension in a pneumothorax is not dependent on the size of the pneumothorax and the clinical scenario of tension pneumothorax may correlate poorly with chest radiographic findings. The clinical status is striking. The patient rapidly becomes distressed with rapid laboured respiration, cyanosis, sweating, and tachycardia. It should be particularly suspected in those on mechanical ventilators or nasal non-invasive ventilation who suddenly deteriorate or develop EMD arrest, and is frequently missed in the ICU setting.[171] If a tension pneumothorax occurs, the patient should be given high concentration oxygen and a cannula should be introduced into the pleural space, usually in the second anterior intercostal space mid clavicular line. Air should be removed until the patient is no longer compromised and then an intercostal tube should be inserted into the pleural space as previously described. Advanced Trauma Life Support guidelines recommend the use of a cannula 3–6 cm long to perform needle thoracocentesis for life threatening tension pneumothorax.[172] However, in 57% of patients with tension pneumothorax the thickness of the chest wall has been found to be greater than 3 cm. It is therefore recommended that a cannula length of at least 4.5 cm should be used in needle thoracocentesis of tension pneumothoraces.[173 174] The cannula should be left in place until bubbling is confirmed in the underwater seal system to confirm proper function of the intercostal tube.[169]

8 IATROGENIC PNEUMOTHORAX

The incidence of iatrogenic pneumothorax is high, outnumbering spontaneous pneumothoraces in several large review series.[175 176] Transthoracic needle aspiration (24%), subclavian vessel puncture (22%), thoracocentesis (22%), pleural biopsy (8%), and mechanical ventilation (7%) are the five leading causes.[173] The two primary risk factors related to the development of pneumothorax with transthoracic needle aspiration are the depth of the lesion and the presence of COPD.[177] To date, no method has been found to prevent pneumothorax following needle aspiration/thoracocentesis. While it was hoped that positioning the patient so that the area to be biopsied was dependent might reduce the incidence of such events, this has not been shown to be the case.[178] The treatment of iatrogenic pneumothorax tends to be simple as there is less likelihood of recurrence. The majority will resolve with observation alone. If required, treatment should be by simple aspiration. Delius and coworkers[58] aspirated up to 89% without resorting to tube drainage using a small 8 F teflon catheter. Patients with COPD who develop an iatrogenic pneumothorax are more likely to require tube drainage,[179] and patients who develop a pneumothorax while on positive pressure ventilation should be treated with a chest drain unless immediate weaning from positive pressure ventilation is possible, as positive pressure ventilation maintains the air leak.[180]

9 CONCLUDING REMARKS

The 1993 BTS pneumothorax guidelines emphasised the place of simple observation and aspiration, reminded junior doctors of the potential hazards of chest drain insertion, and encouraged shorter, safer and less painful treatment paths for many patients. Despite their usefulness, recent evidence suggests that adherence to these guidelines may be suboptimal. This revision endorses the main thrust of these guidelines, with observation for the least severe cases, simple aspiration as the initial treatment choice, and chest drain insertion as a last resort. Recently, the American College of Chest Physicians (ACCP) has published its own guidelines which were arrived at by the Delphi consensus method.[65] These guidelines are similar to our proposed guidelines in many respects, although there are differences such as the emphasis placed on the value of simple aspiration in the treatment of primary pneumothorax. Both sets of guidelines will undoubtedly stimulate debate. The evidence for the current BTS recommendations is incorporated and its weaknesses described. This revision alters the threshold for aspiration in primary pneumothorax and suggests a place for re-aspiration. The limitations of aspiration in secondary pneumothorax are acknowledged, and initial chest drain insertion is recommended for categories of patients where aspiration is unlikely to succeed. These issues are already being revisited as the new "pneumothorax kits" inserted with a Seldinger technique and containing integral Heimlich type flutter valves gain popularity. It is likely that

Audit points

- Proportion of patients treated by (a) simple observation, (b) aspiration, and (c) chest drains and their appropriateness (relative to the guidelines) and outcome (in terms of recurrence rates, complications, and lengths of stay in hospital)
- Number of chest drains clamped and the reasons for this.
- Referral rates to physicians and surgeons and the timing of such referrals.
- Use of analgesics and local anaesthetics.
- Follow up rates

Future potential areas for research

- Prospective randomised controlled trials comparing:
  - simple observation versus aspiration ± tube drainage for primary pneumothoraces larger than 2 cm on the chest radiograph;
  - use of small catheter/Heimlich valve kits versus intercostal tube drainage following failed aspiration in primary pneumothoraces;
  - small catheter aspiration (CASP) versus conventional aspiration or tube drainage;
  - VATS versus open thoracotomy for the difficult pneumothorax.
- Use of suction with regard to its timing and optimal mode.
- Comparison of "clamping" and " non-clamping" strategies after cessation of air leak.

they will prove to be as successful and possibly replace simple aspiration followed by immediate removal of the catheter as recommended in these guidelines.

Several aspects of management that were not previously covered are now included. These include the place of CT scanning in diagnosis, which patients to refer for surgery, a discussion of surgical techniques, and issues such as intercostal tube size and the place of suction and pleurodesis. Complex scenarios including tension pneumothorax, subcutaneous emphysema, pneumothorax in HIV disease and adult CF are also discussed. It is hoped that these changes build on the clinical benefits produced by the first set of guidelines which—if adhered to—should, we calculate, prevent approximately 7000 unnecessary chest drain insertions every year in the UK.

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